

## REMARKS

Applicant has now fully considered the Office Action and the references cited by the Examiner. Applicant notes with appreciation the Examiner's indication that claims 2, 8 and 9 are allowed. Claims 1,3-7 and 10-14, however, have been rejected as originally presented over the references cited by the Examiner. In consideration thereof the claims of this application have been carefully amended to more succinctly define the invention (including claim 8 to improve the wording), and specifically so that all claims thoroughly and patentably distinguish all art of record. Favorable reconsideration of the amended claims is therefore respectfully requested, in view further of the ensuing remarks.

The Examiner has rejected claims 1, 3-7 and 10-14 under 35 U.S.C. 102 (b) over Ziegler et. al., or Tachikawa et. al. '228 or '572, each reference being of record. Claims 4-7 and 10-11 are also rejected over these same references under 35 U.S.C. 103(a). Applicant respectfully traverses these rejections.

Initially it is noted that the rejected claims all relate to use of the method of the invention to produce a superconductor in which the matrix embedded filaments comprise the result of heat diffusing an alloying element from the matrix into the filaments to render the filaments superconductive. As amended, claim 1 now recites that in the case mentioned, the superconductor is  $Nb_3Sn$  and that as the heat diffusion of the alloying element (Sn) from the matrix to the Nb filaments takes place, diffusion of Sn into the electroplated copper stabilizing layer is prevented by means of a diffusion barrier layer.

With respect to Ziegler 3,954,572, the patentee's object is to provide an electroplated alloy coating over a copper matrix, which coating includes an element (Sn) to react with the Nb filaments embedded in the matrix to form  $Nb_3Sn$ . This is accomplished by heat diffusing the element (Sn) through the existing Cu matrix. The object of the present invention, however, is to

provide an electroplated stabilizing element. If diffusion were to take place from an alloy into the electroplated copper the stabilization would be defeated. Also, forming a compound with any element removes the stabilizing copper. In the present invention a barrier is utilized (and recited in the claims) which prevents this from happening. A barrier in Ziegler would prevent the diffusion, Ziegler seeks and no reaction could take place. In the applicant's invention the stabilizing layer is electroplated before the heat diffusing, and the diffusion barrier layer protects the electroplated copper.

Ziegler also states at column 5, lines 53-60 that Cu can be deposited as a stabilizing layer after heat-treatment. Applicant's Claim 1 further now recites where the filaments comprise Nb and the alloying element diffused from the matrix is Sn, (which thus produces Nb<sub>3</sub>Sn as the superconductor), that when the heat diffusion step is carried out the electroplated assembly is in the form of a magnet coil. Support for this last limitation is found at page 6 lines 22-23. Almost all magnets are made by the technique called "wind and react." In this technique the conductor must not be reacted to form the Nb<sub>3</sub>Sn prior to coiling since the Nb<sub>3</sub>Sn is too brittle to be formed into a coil of the diameter required. In applicant's invention in addition to a barrier being required, the diffusion to form Nb<sub>3</sub>Sn is only carried out subsequent to the coil being formed - see amended claim 1.

MRI magnets and accelerator magnets are all prepared by the wind and react method. Large fusion magnets such as the "Cable in Conduit Conductors" are reacted prior to winding. The non-reacted wire is first cabled and the cable is inserted into the conduit. This assembly is then coiled and heat-treated after which the magnet is wound. Even in this case Ziegler's process could not be used since he must heat-treat, then plate the wire, then cable. The superconductor properties of the wire will be completely destroyed in the cabling operation. In Applicant's case the plating is done on non-heat-treated strands (which can be done because of the barrier), the

strands are cabled, inserted into a conduit, coiled or spooled up and then heat-treated. The magnet coil is then wound in the heat-treated condition, as is normally done for these huge magnets.

Tachikawa 4,435,228 relates to a process for producing  $\text{Nb}_3\text{Sn}$ . Col. 3, lines 55+ describes coating tin (which can be alloyed with small quantity of Cu) by electroplating and then heat-treating. Electroplating a stabilizing layer of copper (much less protecting such copper by a barrier layer) is not mentioned and the object of the tin plating is not for stabilization, *e.g.* the patentee recites coating the conductor with tin and heat-treating to diffuse the tin into the matrix to form  $\text{Nb}_3\text{Sn}$ . No stabilization is obtained. It is difficult to use the wind and react process and precautions are required to prevent the tin from non-uniformly diffusing into the matrix. No barrier can be used since the object in this patent of the tin plating, is to cause it to diffuse into the matrix to form  $\text{Nb}_3\text{Sn}$ . Applicant's object in its electroplated layer is not to diffuse anything, but rather to provide a stable coating that remains pure and has a high conductivity to provide stabilization. The plated copper does not enter the reaction to form an A-15 compound.

In Tachikawa 4,341,572 at columns 2; line 55+ and column 3, lines 50+ the coating of copper is used to provide a matrix to diffuse tin into the interior of the conductor to form  $\text{Nb}_3\text{Sn}$ . The tin is deposited after all the drawing is finished. Upon diffusion the copper cannot provide any stabilization since the residual tin destroys its electrical conductivity. Applicant's process provides copper for stabilization, and upon heat-treating nothing is diffused into the barrier-protected copper since this would destroy the objective of providing a high conductivity product for stabilization.

The electroplated copper in Tachikawa '572 at Example 2 (lines 5-45) contains tin and cannot stabilize the composite, again because of the poor electrical conductivity. It should be remembered that after diffusing tin from a copper matrix or coating, the residual tin left in the copper is of the order of 2 or 3% by weight. Such an alloy is a very poor electrical conductor

compared to electroplated copper. The RRR of pure copper is 100 or more, whereas even as little as 0.5% tin or most any other element in the copper the RRR will be less than 10. Therefore the conductivity of the electroplated copper is at least an order of magnitude better.

In Tachikawa '572 the coating or plating cannot be done with a barrier since this would prevent the external diffusion of the tin and prevent the formation of the  $\text{Nb}_3\text{Sn}$ . Also their coating or plating does not provide stabilization. Applicant's coating depends on there being a mechanism which prevents the diffusion, other than that required for bonding, to maintain a pure copper coating.

Kikuchi et al. (cited by the Examiner but not applied in rejection) relates to production of  $\text{Nb}_3(\text{Al}_3\text{Ge})$ , a product not encompassed in applicant's amended claims. In this patent it is stated (column 5; line 45) that the copper stabilizer can be applied by any means including plating. However, the deposition of the copper is always added to a fully reacted conductor. In Applicant's process where  $\text{Nb}_3\text{Sn}$  is the superconductor, a non-reacted conductor is plated to be used in a wind and react mode. This cannot be done in the Kikuchi patent, because of the nature of the formation process used.

The reciting of exact ratios, *e.g.* page 8 of the present application does not refer or relate to any ratios that may be in the above mentioned patents. All the ratios cited in the Examiner's rejection are concerned with producing  $\text{Nb}_3\text{Sn}$  and having the proper ratios to produce a stoichiometric compound. Applicant's statements concerning ratios is for practical applications of copper plating. The initial ratios Applicant disclosed are very low ratios of copper for economical processing of the conductor. The ratios after plating copper (no diffusion of material into the matrix) is to provide the proper stabilization required by the magnet designer. These ratios would prevent the proper stoichiometry of the desired compounds being formed if used as applied to the formation of  $\text{Nb}_3\text{Sn}$ . The stoichiometry is not a concern in Applicant's copper

plating. Applicant is only concerned that the amount of copper provides the desired stability and that a wind and react process can be employed. Applicant does not effect the formation of Nb<sub>3</sub>Sn by plating copper. Applicant does require that no diffusion into the copper take place. This implies a barrier to prevent contamination of the copper. This precludes the application of any of the above-cited patents since they all require external diffusion and plating cannot be done prior to reaction for a wind and react process.

In view of the amendments introduced by the present paper. and in consideration of the foregoing remarks, it is submitted that all claims as now presented are fully allowable, whereby favorable reconsideration and an early Notice of Allowance are respectfully requested.

Respectfully submitted,



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